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as an ultimate fact.''[11] The realist is perfectly willing to accept it as an ultimate fact if thereby he is enabled to accept the other ultimate facts that the idealist seems so desirous of accepting, namely, that what we perceive is the very object itself, that there are various events that functionally mediate the object and the brain event with which consciousness is correlated, and that these events interpose a time interval between the date of the object and the date of the awareness. The realist finds it easier to accept ultimate facts than contradictions and fallacies and jugglings with perceptions which make the same perception now actual and now possible, now present and now past—legerdemain of the ''now you have it and now you haven't it'' kind. He has to accept ultimate facts sooner or later anyway, and he can not see how an ultimate connection becomes any the less ultimate when it is smuggled into a bag labeled ''similarities,'' wherein he is assured that one can ''begin to 'see the effect in the cause.' '' That bag seems rather to hide the ultimateness than to remove it.

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# ATTENTION FATIGUE AND THE CONCEPT OF INFINITY

IT is the purpose of this paper to suggest a relation between the smothering or diffusion of attention found as one element of intellectual fatigue, immediate or cumulative, and the metaphysical concept of infinity in the sense of the unlimited and unconditioned.

In any concept we may have, of course, either purely word-images or images visual, auditory, kinesthetic, etc., of the object or of the relation or series of objects and relations. Let us call them content-images to distinguish them from word-images and from the secondary representations, visual, auditory, kinesthetic, etc., of word-images. Much of our thinking is carried on in terms of word-images or of the secondary representations of them. As in pure mathematics or in purely formal logic—such as the work of Peano, Schröder or Bertrand Russell—we can manipulate symbols, regardless of the content represented by these symbols, so in much of our ordinary thinking we make large use of merely word-images. But for any except this formal type of reasoning we have to use content-images. Thus if we examine discussions of the metaphysical concept of infinity, as in Spinoza or Kant, we find the use of something more than mere word-images. We find content-images. For instance, in Kant's first antinomy the whole discussion is based on an attempt to analyze the content-images and to see how it is possible to think them in each case.

Having distinguished between content-images and word-images, and having seen that discussions of infinity involve content-images, let us see what is the nature of the content-images used. If we examine such as are actually used, we invariably find as one element such a form of the images that the attention is inevitably smothered. Let us quote as illustration from answers given to this question, "What images do you discover when you think of such abstract ideas as goodness, law, infinity, beauty, force, cause and effect?"[1] Those referring to the idea of infinity were as follows: "Space in a whirl," "A whirling, whirling ball," "Line extending through the sky," "Infinitely long, white straight line," "Space—blue, fluffy, misty clouds," "Mist-filled, colorless space extending forever and ever," "Space filled with subdued light, something like fog," "Sky at night with stars and milky way, etc." (several used images of sky in various forms), "Waves rolling on the beach," and several mathematical representations like "curve approaching $Y$-axis," "parabolas," "parallel lines," "circle." If we examine these, we find each of them involves an undifferentiated something as an invariable feature. Space is whirling, whirling so that its different positions are not fixed in attention; the line extends through the sky, long, white, unending, unchanging; the fluffy, misty clouds, the mist-filled, colorless space, the subdued light, all give as an invariable feature the very undifferentiated character which is sure to induce smothering of attention. The same is true of the waves rolling on the beach. That element in the image which represents the infinity is the fact that one wave follows another without change, the undifferentiated character of the process. Further examples could be added: "falling over the edge of the world into space,"[2] where the undifferentiated character appears in the succession of the imagined positions in the process of falling; the number series[3] considered as a process of manipulating digits, although this usually involves mere word-images. Kant in his first antinomy uses as the content-images a series of worlds, a repeated synthesis of parts, empty time and empty space,[4] in all of which the undifferentiated element is evident. The same is true of any self-representative series, of which form Professor Royce[5] has made so much. The baking-powder box having on its label a picture of itself and in this picture another picture of itself and so on is an example of such a self-representative series and shows the essential feature of that series to be, not the differences in the pictures, but the unvarying repetition of the series itself.[6] We find, then, in all the content-images cited, as an invariable element an undifferentiated character which is sure to smother attention.

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[1] For the use of these answers I am indebted to Mr. W. V. D. Bingham, of the department of psychology, University of Chicago. This question was one of several relative to ideational type submitted to students in introductory psychology at that institution. I have made no attempt at quantitative results except as is involved in the statement that, so far as *any* content-images were found, they all had the element noted.

[2] Illustration of how a child gets the concept in Baldwin's "Dictionary of Philosophy and Psychology," Vol. I., article on "Infinite and Infinity."

[3] *Ibid.*

[4] *Cf.* "Critique of Pure Reason," Müller's translation, 2d Ed., pp. 344–347.

Having found that this smothering of attention is an invariable element, we turn to inquire if it is not the essential element, if it is not the element by virtue of which these content-concepts are concepts of infinity, if it is not the element which, if lacking, would make the concept not a concept of infinity. We find that just in so far as we do have differentiation we say that we have not the concept of infinity. Thus in trying to form a content-concept of infinite time preceding the present moment, we may jump back over historical and geological periods, alighting momentarily on the thought of pyramid builders, of the first savages to use fire and stone implements, of the time the world was flung off from the hasty pudding of the sun and so on. There is, it is true, differentiation in this concept. There are alighting places for attention, but for that very reason we say that they do not even in combination represent infinity. The very fact that they can be differentiated and held in attention makes us say that they do not represent infinity. The more they can be differentiated, the more easily they can be held in attention, the less adequately do they represent to us infinity. The less differentiated they become, the more nearly they assume that character which shall smother attention, the more nearly we say they approximate the concept we are after. In these content-images cited, then, this smothering of attention is not only an invariable attendant, but also the essential element, that without which the concept would not be a concept of infinity. Since this smothering of attention is an essential element in these concepts, since we can not find any content-concepts in which this is not an essential element —although recognizing the inconclusiveness of this negative part of the argument—we are led to suggest that the concept of infinity is the metaphysical correlate of that which on the psychological side is smothering of attention. This smothering of attention is, of course, itself a symptom of certain molecular conditions of cortical and peripheral cells which we can at present but fragmentarily describe.

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[5] "The World and the Individual," Vol. I., p. 501 ff.

[6] *Cf.* for further illustrations "The Infinite New and Old," J. A. Leighton, *Philosophical Review*, September, 1904.

One question may arise. If smothering of attention is the essential element in content-images of infinity, why does not every case of the smothering of attention give the concept of infinity? If we attend long enough to a single element of any image, for instance, the image of a desk-pad, we shall secure smothering of attention, but no concept of infinity. The answer, of course, is that in these latter cases the smothering of attention is one element of the process, but not the essential element. We do not say, in the case of the desk-pad, that the more undifferentiated our image of it becomes, the more nearly smothered our attention is, the nearer we are to a content-image of the desk-pad. But in the case of the concept of infinity we do say just this. The more undifferentiated the image the nearer it comes to being the concept of infinity. In short, the smothering of attention in the concept of infinity is the essential element, in the case of the concept of the desk-pad, an irrelevant attendant circumstance.

We have distinguished between two kinds of concepts, or images used as signs of bundles of experiences, word-images and content-images. We have seen that content-images are necessary for any description or argument, such as is found in the discussions of infinity by Spinoza and Kant. We have found that an invariable element in all content-images of infinity is an undifferentiated character sure to induce smothering of attention. We have pointed out that this smothering of attention is not only an invariable, but also an essential, element in the concept of infinity, and hence we have suggested that attention fatigue is the psychological correlate of the concept of infinity.

From this grow two or three other suggestions. One is relative to mystic states in which oneness with the infinite is such a prominent feature. As Pillsbury[7] has pointed out in the case of fluctuations of attention to minimal sensory stimuli, cumulative fatigue after a long period of work is likely to extend the periods of smothering of attention in immediate or temporary fatigue. In other words, when the organism is fatigued after prolonged nervous work or excitement we may expect the smothering of attention to be especially easy. In mystic states we find these very conditions of excitement and fatigue which would make the smothering of attention readily inducible. We find those conditions which would make the organism fallow for suggestions of the infinite.

A second suggestion is relative to a psychological interpretation of a well-known metaphysical position. Kant in his treatment of that field in which judgments involving infinity are in order, in his treatment of the realm of things-in-themselves, says that they never can be known, but must be thought.[8] It is interesting to translate this observation into terms of physiological psychology. The infinite can not be known because knowledge involves the flitting of attention over the different features of any given percept or idea. Any attempt to know the content of the concept of infinity necessarily involves imagery sure to diffuse and smother the attention, and thus make knowledge of it impossible. By an automatic device attention is scattered and the knowing process stopped when turned to consider the concept of infinity. On the other hand, Kant says while it can not be known it must be thought, that is, these states of smothered attention are facts of experience and must be represented by concepts such as those of infinity and things-in-themselves.

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[7] *American Journal of Psychology*, 1903, p. 541 ff.

The third suggestion is relative to an avenue of approach to questions of the physiological basis of metaphysics. It may be felt that the serious consideration of such questions in the present state of physiological psychology is foolhardy, that the problems of localization of function in the cortex and of the vicarious functioning of certain cortical centers for other cortical centers are at present too unsettled to allow of any such consideration, except, perhaps, as pipe-dreams of a psychologist after his regular day's work is done. But the foregoing study is just such a reaching out after a hint on the physiological processes underlying metaphysical concepts. We have tried to find out one of the psychological elements, namely, attention fatigue, which goes along with one type of metaphysical experience, namely, the concept of infinity. We have tried to reduce part of our problem to terms of attention fatigue. But the problem of the physiological basis of attention fatigue does not seem entirely hopeless to the physiological psychologist.[9] This problem seems to offer him a handle as that of the physiological basis of a metaphysical concept does not. If we can establish a relation between the concept of infinity and attention fatigue we may be able to use some of the experimental data on the physiological correlates of attention fatigue to help in the larger problem. We recognize, then, that in speaking of this concept in terms of attention fatigue we are speaking in terms of a psychological symptom of a physiological state, of the precise nature of which physiological state we are still largely ignorant. We see, however, that if we establish a relation between the concept of infinity and attention fatigue this relation will not be disturbed by further light on the molecular changes underlying attention fatigue. This relation will put us a step nearer discovering the physiological basis of one metaphysical concept.

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[8] *Op. cit.*, p. 207 ff.

[9] *Cf.*, besides the works of Wundt, Münsterberg, Lange and others on fluctuations of attention, W. MacDougal on the "Physiological Factors of the Attention Process," *Mind*, Vols. XXVII., XXVIII.

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## REVIEWS AND ABSTRACTS OF LITERATURE

*Plant Breeding.* Comments on the experiments of Nilsson and Burbank. HUGO DEVRIES. Chicago and London: The Open Court Publishing Co. Pp. vi + 360.

This work of deVries's is primarily devoted to an exposition of the methods followed by Nilsson and Burbank, but of equal importance and interest is the attention that is given to his theory of evolution and mutations.

The work of Nilsson, which will revolutionize plant breeding and open fields of scientific investigation of fundamental importance, has heretofore been concealed from the public owing to the fact that he has entirely disregarded all educational aims and purely scientific researches. His sole effort has been directed to the amelioration of agricultural crops, but it should be added that his work is based upon the most exact and scientific methods. This report of deVries's will bring amazement when it is learned that in the little Swedish village of Svalöf, opposite Copenhagen in Denmark, results have been obtained and principles have been discovered during the past fifteen years which exceed in importance all the achievements in agricultural history.

This work was started owing to the slow but manifest deterioration of various agricultural crops, which lessened the value of the harvests in an important degree. A few Swedish farmers formed a company in 1886 at Svalöf for the purpose of procuring and testing new foreign varieties of seeds in order to replace the inferior Swedish varieties. Naturally, the German method, which was most widely practised at that time, of improving the quality of the grain, was followed. The practise was to select numerous examples of the best specimens of a particular crop, *i. e.,* make a "multiple selection," and this *élite* stock was sown, and similar selections were again made from it. Year after year the best examples were chosen from the successive crops, and slowly and gradually the qualities were supposed to improve in the direction desired. While important additions were made by this method to several varieties of grains during the early history of the company, a more important fact became obvious, that success was the exception, and it soon became a demonstration that the old idea of the arbitrary control of the qualities of a plant was manifestly untrue. It became evident that the plant develops after its own nature and can not be forced into other ways.

It was at about this period in the history of the work (1890) that